DIGITAL TERRAIN MODELS IN TOURISM: AN INVESTIGATION INTO THE DEVELOPMENT AND USE OF COMPUTER-GENERATED 3D VIEWS FOR ROUTE-FINDING IN MOUNTAIN AREAS

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Abstract

This project investigates the potential of computer-generated oblique views of landscape terrain models to assist hill walkers with orientation and navigation in mountain wilderness areas. Extensive evidence exists for the interpretive support value of such 3D images in many fields, in both manual and computer modes. While there is now scope for the creation of animated flybys to permit prior investigation of virtual landscapes, this study concentrates on the potential for single or small series of such oblique views to be used as printed hard-copy. This study examines some of the problems associated with the production of such views, including the creation of DTMs and the surface draping of both classified satellite images and cartographic symbols. Early reports on the field-testing of resulting experimental products have proved to be positive and have encouraged continuation of the programme.

1. Introduction

1.1 Background:

Learning to read detailed topographic maps, especially for serious activities such as navigation in mountain wilderness areas, includes the orientation and matching of the interpreted map image to the terrain in view. Many travellers, experienced mountaineers and orienteers have developed such skills and, if lost, could probably map-read themselves out of difficulties. However there is an increasing number of 'occasional' hill walkers who do not have this level of skill and confidence. This paper reports on a study directed primarily at the needs of this latter group.

The familiar characteristics of the pictorial panorama (or panorama-like) map have provided more user-friendly images for tourists in some regions for at least a century. While not suitable for navigation the engraved mountain views of nineteenth-century tourist guide-books were easier to read than either maps or even photographs of the same landscape. Evidence of the interpretive-support value of such pictographic images exists in many fields (e.g. military, architecture, planning) and they have become established in the tourist publicity literature of regions such as the European Alps. One of the main problems in the past, however, has been the difficulty, time and cost of creating such views manually. In most cases only one viewpoint has been offered for each landscape subject. Also, as they were generally created by graphic artists, their pictorial appeal normally embodied a variety of spatial distortions which restricted their acceptance as anything other than a 'picture' of the landscape. It has been noted that while images such as these may be accepted as map-like they will not be recognised as falling into the core 'map' category, especially by non-expert map users. Is there any scope, therefore, for raising their status from mere pictures to offer a more valuable supportive role for mountain/wilderness awareness and navigation?

Modern computer terrain modelling techniques have banished many of the construction problems associated with such panorama work. With current software (and the appropriate digital data) it is now relatively simple both to create oblique views of landscape from digital elevation models and to provide screen-based virtual journeys ('flybys') over the landscapes to be visited. But the time has not yet come when the paper map and magnetic compass can be challenged on cost and portability by technologies such as GPS and portable animated maps. Many tourists may take time to adapt to such products, preferring more traditional (and, initially, cheaper) navigational aids. So there may still be scope for the printed paper product! It is obvious that any combination of viewing parameters can be chosen for a digitally-generated oblique view. Nor need there be restriction to a single 'ideal' viewpoint. Also, additional spatial data (abstract or mimetic) may be draped on the model's surface to produce the effect of a much more map-like landscape visualisation. Interactive selection of viewpoint and surface coverages can thus permit the composition and production of one or sequence of such map-derived images for the region to be visited. This could offer a usable intermediate facility between the original single static paper map and a more complete viewing of an animated fly-by of the area of interest. Previous research suggests that such graphic 'devices' can help users interpret conventional contoured maps ( ), build mental models of the landscape and thus, if used in the field, offer some assurance to the less experienced. There may also be some more geographically-restricted regions where one or two carefully-selected and crafted views could even substitute, reliably, for a map.

The on-going study of which this report forms a part concentrates on the compilation, design and field-testing of such computer-generated oblique views.

The author has used the more manual/artistic techniques of block diagram and panorama construction (Wood, 1986) and has been aware of their limitations beyond publicity applications. It was thus natural for him to investigate some of the computer alternatives. As most of the readily available 3D software in the 1980s provided only for construction of fishnet-type surfaces, revival of active interest in the applications of the digital approach did not occur until the availability of more sophisticated packages (Wood, McCrorie, 1993).

1.2 Procedure and findings:

Some preliminary research which preceded the current programme explored the level of acceptance and possible field applications of DTMs with solid surfaces and draped features (McCrorie, 1995). The present phase (instigated by an EOSAT grant) has attempted to build on that work. Using detailed digital terrain data, ERDAS image processing and ARC/INFO GIS software, a series of experimental oblique views were produced and tested, in a pilot study, for their acceptance and perceived value to aid terrain recognition and route planning. The results which are now forthcoming suggest a strong degree of optimism for the potential of digital products in the tourist context. However it is recognised by those tested or interviewed that increased confidence in them will depend on their design and content and also on their acceptance by experienced and informed hill walkers.

2. Methodology of the Scottish Cairngorm Project

Although data was originally obtained, and work carried out, on two areas, in Scotland and Lake Louise, Canada, this report focuses on the former. EOSAT supported investigation into the possibilities of using classified Landsat imagery as surface ground-cover for such terrain model maps and additional aid was obtained, in particular, from the Harvey Map Service, which provided the digital terrain data.

2.1 Aims and Objectives:
The aim of this part of the on-going study was to create a series of appropriate oblique views of the Coire Cas area of the Scottish Cairngorm Mountains, which has been developed for both summer and winter tourist activities - summer and winter. Pilot tests would also be carried out to test the application of such images beyond their more traditional publicity role. To achieve these aims the following objectives were listed:

1. Create a DTM of the area of interest.
2. Derive appropriate oblique views using ARC/INFO modules.
3. Select the content for the draped overlay (abstract map symbols and also mimetic classified
   satellite images from ERDAS).
4. Carry out preliminary tests on sample hard copies of the resulting views.

At this stage of the study no account was taken of relevant human factors of the test subjects. The intention was to create images easily comprehensible to users with minimum knowledge of map reading. It was appreciated, however, that different levels of map-reading skill, spatial ability, knowledge and experience of mountain navigation and, possibly, knowledge of the study region, would combine to influence the outcome of the more rigorous tests planned for the next stage.

2.2 Creation of the DTM and prototype oblique views:
Original digital data derived directly from photogrammetry included all the information appearing on the published Harvey Mountain Map of the area (1:40 000), i.e. detailed point and line symbols and digital contour data. The style of these Mountain Maps, rich in topographic detail, is derived from the orienteering maps which Harveys has specialised in for many years.

The DTM was built from the digital data within ARC/INFO, using the TIN and Lattice procedures. Since the satellite image is a rasterfile the TIN model was also be converted to raster so that the image could be draped over the DTM. The simplest way to view a DTM in ARC/INFO is to drape it with analytical hill shading in which the illumination azimuth and elevation, the observer and target positions, the surface area, the field of view and various other viewing parameters are specified by the user. Hence the DTM can be viewed from any position with hill shading selected to illuminate the model to best effect.

For the purpose of this project the Landsat images were subset to match the areas of the maps. They were originally provided with a pixel resolution of 28.5m. However, once within ARC/INFO this grid can be re-specified to any dimension and in each case the pixels were matched in both model and imagery. It is possible to reduce the grid size to help eliminate any visual noise created by the pixel patterns, although, being displayed in 24-bit colour, this will obviously increase storage requirements. The smallest grid size used in this project was *15* m.

A number of image processing techniques, performed in ERDAS 7.5, were required to render the satellite imagery suitable for importing into ARC/INFO and draping over the DTM.

The best image had minimal snow cover, small shadows, good visual appearance and clarity of different vegetation types. The processes applied helped to enhance the appearance of true vegetation colour and, especially forests and water bodies. Attempts were also made to reduce the effect of shadowing and overcome sharp contrasts. Draping of the ERDAS-generated images directly within ARC/INFO 6.1.2 is easy but not very effective as it suppresses the relief. Better results can be achieved by other means:
(a) Converting the image to a set of grids (one grid for each band) allows for manipulation of the colours to obtain the best and most realistic displays. All the work in this project used combinations of bands 1-4.

(b) Hue was calculated for 3 bands using the RGB Hue Converter in ARC/INFO. The saturation was similarly calculated. The third component, value, was calculated from a combination of up to 3 grids of analytical hill shading. The hill shadings were treated as RGB components and computed to a single grid - the value (intensity). This method has been shown to produce the best results since the angles of artificial illumination can be carefully selected to reduce and even eliminate the effects of shadowing in the image, caused by the azimuth and altitude of the sun. The best results obviously occur with images where the sun is highest, i.e., in summer, when detail regarding the ground cover can be enhanced.

(c) Draping the HSV (Hue Saturation Value) components on the surface of the DTM creates pseudo-colour images. Converting HSV to RGB can give near perfect true colour or false colour composites draped on the surface. The resulting output is 3 grids, one for each of the red, green and blue.
(d) It is then a simple case of draping a grid composite of the 3 colours over the DTM in ARCPLOT.

Various methods were then attempted, in ERDAS, to create a classification of land cover types. Forested areas in particular classified very well and the resulting GIS file converted to a polygon coverage in ARC/INFO and then draped on the image. This improves visual understanding of image colours, especially if a false colour image is used. Probably with the exception of lochs, extra classifications, such as scree and marsh, generally add to the confusion of the image. This tends to distract from the usefulness of the textures contained within the image, and leads to a cluttered and confusing map at the size of output considered in this experiment.

In ARC/INFO it is possible to use the forest coverage to modify the DTM and include the forest canopy as the surface in the model. This has potential for considering line of sight, visibility analysis, etc., from a given viewpoint. However in this instance and at this scale the effects from adding the height of vegetation to the model were negligible and could not be seen in the output without undue exaggeration.

The final stage in the production of the 3D views was draping of the cartographic vectors over the surface. The data containing streams and tracks, for instance, were more of a problem than was elevation to reformat for ARC/INFO because the topology of the individual arcs had to be retained. Appropriate coverages were, however, generated in ARC/INFO which then could be draped on the model. The attribute information was then used to differentiate between different types of tracks and paths, for example, displaying them with line symbols selected by the user. Some final products were thus created but, at that point, the addition of all map detail and names had not been completed.

Finally, colour hard copy output was created on a number of different PostScript printers but limitations of the 300 dpi resolution reduced their final quality.

2.3 Preliminary Testing of the new products
The final stage was to test the potential of these new images on target groups such as occasional walkers, opportunist mountaineers (making use of the easy road access to the hills) and also more serious climbers.

Results and conclusions

At time of writing only one pilot study has been undertaken due, partly, to the difficulty of producing coloured images of satisfactory quality and detail. A special questionnaire was prepared (to accompany the sample products) and preliminary analysis has produced some interesting results. The subjects were VERY critical of these early attempts at 3D map-like images but positive responses did emerge.

The questionnaire was 7 pages in length and included both a coloured image and a copy of the relevant part of the Harvey Mountain map. Explanations of methods, etc., were provided within the text, and main questions centred round three key topics which generated the following responses:

- Route planning: The 3D images were regarded as useful for many of the preliminary tasks of route planning but lost their popularity when it came to on-going navigation.
- As a map-substitute? Despite the negative bias in the above section some subjects could see beyond the fairly course quality of the sample image and believed that there would be some circumstances where the 3D view might be able to operate virtually alone.
- As an aid to safety? Some respondents even gave modest recognition of the possibility that high quality versions of such accurate, map-related 3D views could be of serious benefit to the improvement of mountain safety!

Experiments are continuing with modifications being made, in particular, to the design and content of the surface details. More rigorous experiments have been planned to test these products in field use and amongst hill walkers of different levels of knowledge and experience.

References

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